Tactical DIRCM Jamming Pod — Early Operational Assessment

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Introduction: Infrared-guided surface-to-air missiles (SAMs) and air-to-air missiles (AAMs) continue to pose grave danger to U.S. Navy and Marine Corps aircraft. Current tactics against these threats include the execution of evasive maneuvers and the dispensing of flare countermeasures. Improved self-protection capabilities that are essential to enhance aircraft survivability include: 1) the deployment of passive missile warning technologies capable of providing the earliest detection of the threat missile plume ignition and 2) the development of more effective covert laser-based countermeasure techniques. We describe here the development, fabrication, and testing of an operational prototype pod designed to protect U.S. Navy tactical aircraft against the most advanced infrared (IR) guided missile threats.

The TADIRCM EOA Pod: NRL's Tactical Aircraft Directed Infrared Countermeasures (TADIRCM) system is comprised of a suite of wide field-of-view (FOV), passive, two-color, IR missile warning sensors, a computer processor (CP), and an active, all-band, IR jammer. As part of an Early Operational Assessment (EOA) program, these subsystems have been assembled into an autonomous pod to be used for determining the suitability of NRL's technologies for deployment in a tactical airborne environment. The TADIRCM EOA pod is populated with six sensors, built by DRS Infrared Technologies, which provide full spherical coverage except for the limited area blocked by the aircraft. The sensors are based on a 256 × 256 pixel mercury cadmium telluride focal plane array (FPA) that is configured as a stacked detector to provide simultaneous and co-located two-color operation. The two-color IR imagery is transmitted to an NRL-built missile warning processor for autonomous detection of threat missile plume signatures. Following rapid declaration, the threat location is conveyed to the laser-based IR jammer (Agile Eye-II), built by BAE Systems. Agile Eye-II is a fast-steering gimbal capable of directing a beam of modulated infrared radiation toward the approaching missile. The infrared radiation, generated by the Tactical Multiband Infrared Laser, is modulated in a manner to create a series of one or more virtual targets within the missile seeker's FOV. These jamming codes force the missile seeker to track false targets and steer its tracking mirror away from the targeted platform. Optical break-lock (OBL) is achieved when the missile seeker's tracking mirror has been steered to a point where the targeted platform is no longer within the seeker FOV. During TADIRCM EOA testing, NRL-based jamming codes were used with great effectiveness. Figure 4 shows the hardware comprising the TADIRCM EOA pod and the pod on board station 2 of the test FA-18 aircraft.

EOA Tests: TADIRCM EOA tests were carried out both at the Atlantic Test Range (ATR), Naval Air Station, Patuxent River, MD, and at the China Lake Naval Air Station, China Lake, CA. The ATR tests established the airworthiness of the EOA pod during a captive carriage flight. Three additional flights were performed to obtain functional operational integration data for NRL's Missile Warning Set (MWS) and BAE's Agile Eye-II jammer subsystems.

EOA China Lake Flights: China Lake testing of the TADIRCM EOA pod was carried out in four flights. In the first three flights, the various timelines of the integrated system were established. To do this, the setup illustrated in Fig. 5 was adopted with five missile-launch stimulator sources. Repeated passes of the FA-18 aircraft over the China Lake airfield provide performance data of various scenarios likely to be encountered in close air support missions of this aircraft. Each of the sources in Fig. 5 is comprised of a set of propane burners designed to generate infrared signatures with spectral characteristics similar to those of a threat missile. The TADIRCM MWS algorithms track spectral and temporal features to discriminate fast ignition-like events from potential false alarm events. During China Lake tests, the ignition sequence of the threat simulators exhibited sporadic dropouts. In these instances, the simulated events were not declared by the MWS as valid threats and were not included in the determination of system performance metrics as they do not properly represent an attacking missile.

The five stimulator sources used in EOA tests were: 1) the OBE/WAAN instrument, which is capable of determining the centroid and spatial extent of the Agile Eye-II laser beam; 2) a set of burners at the NRL surrogate location, so designated because of the presence of a surrogate imaging threat seeker; 3) the Center for Counter Measures (CCM) seeker van, which included a number of foreign and domestic threat seekers used to evaluate the effectiveness of NRL's jamming codes; and 4) two IR Stimulator/Target Array System (ISTAR) sources.

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Sample TADIRCM EOA Performance: A typical flight over the China Lake airfield is illustrated by the results shown in Fig. 6, which portrays pass 12 on March 16, 2007. Five sources were used in this engagement. Two of the sources were deployed twice, resulting in a total of seven engagements. In Fig. 6, light blue indicates the time over which the burner is active, i.e., it denotes truth for the particular event. Below this sequence, the performance of the MWS is illustrated. Specifically, green denotes the start of a track, and red denotes the declaration of that track as a missile threat. The status of the jammer is presented in the third bar sequence in dark blue. Note that the MWS starts tracks without failure at the same time as the missile plume stimulator is engaged. Also, note that each of these tracks is declared a threat in each of the engagements shortly after track initiation. This pattern of events (track initiation followed by a rapid track threat declaration) was observed in 96% of all valid engagements during EOA testing.

During single threat events, the IR jammer is cued into action at the time the track is declared a valid threat. The time at which laser energy is delivered to the attacking threat is given by the solid blue bar in Fig. 6. Thus, the interval between the onset of threat declaration and the onset of laser on target represents the time it takes for the Agile Eye-II to slew to the threat location, acquire the target, and establish a stable track.

We note that many of the events in EOA testing were designed to simulate simultaneous threat engagement scenarios. In particular, the events in Fig. 6 labeled 168401 and 168444 are simultaneous threat engagement events. During all these events, the TADIRCM EOA pod correctly jammed the first such declared event and then proceeded to engage the subsequently declared threat. In some of the longer burning instances, we observed the system re-visit an already jammed threat once all other pending threats had been properly engaged.

TADIRCM EOA IR Jammer Performance: The CCM seeker van test facility was used to test four seekers. The seekers available for this test correspond to a domestic threat, an air-to-air threat, and two commonly available SAM threats. Propane burners co-located with the CCM seeker van were used to stimulate the TADIRCM MWS. A variety of detectors at the CMM facility measured the time at which laser energy was delivered to the simulated threat as illustrated by the dark blue bars in Fig. 6. Of course, also measured was the time it took for a particular seeker to be defeated. This time depends on the order in which a given jamming code is delivered.

Summary TADIRCM EOA Performance: Table 1 provides the statistics for system performance. The MWS performance is expressed as the percent of valid threat events where the system rapidly declared the simulated threat event. The IR jammer performance is expressed as the percent of valid MWS declarations where all tested seekers were successfully defeated by the NRL jamming codes.

The performance of NRL's TADIRCM system during EOA tests, as summarized by Table 1 above, is excellent. Based on these results, the Navy's Operational Test and Evaluation Force is recommending the TADIRCM EOA pod for deployment in tactical platforms. In addition, the Naval Air Systems Command is beginning an acquisition program for the deployment of NRL's MWS technologies for the protection of Navy and Marine Corps rotary wing platforms. Continued work remains in this NRL project to provide indication of the presence of ballistic weapons and navigational visual aid to the pilots.

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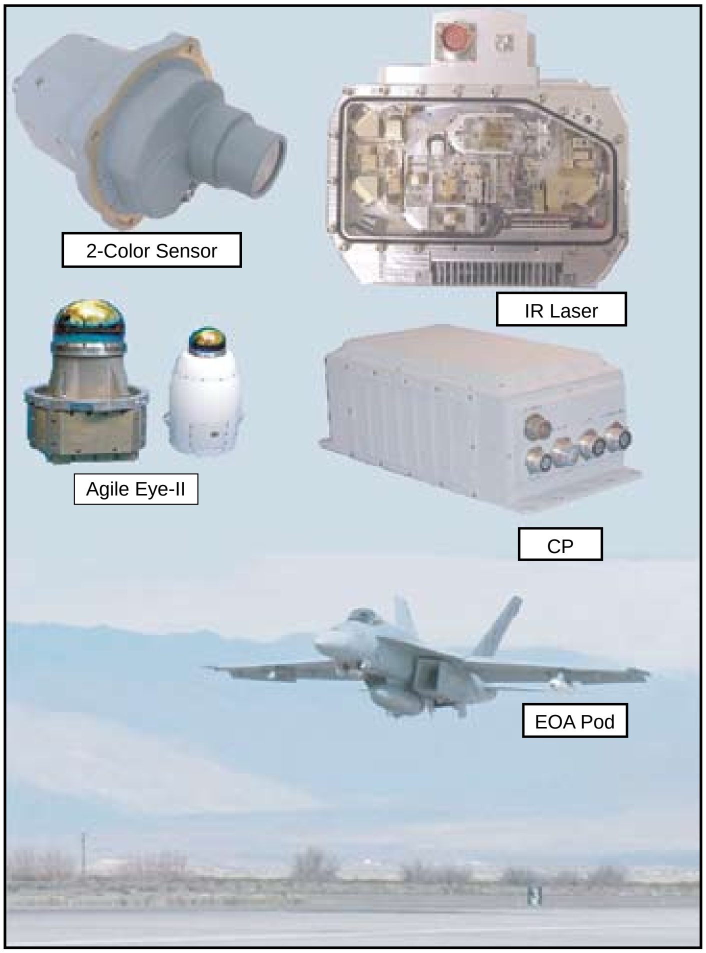

FIGURE 4
TADIRCM components and the EOA pod.

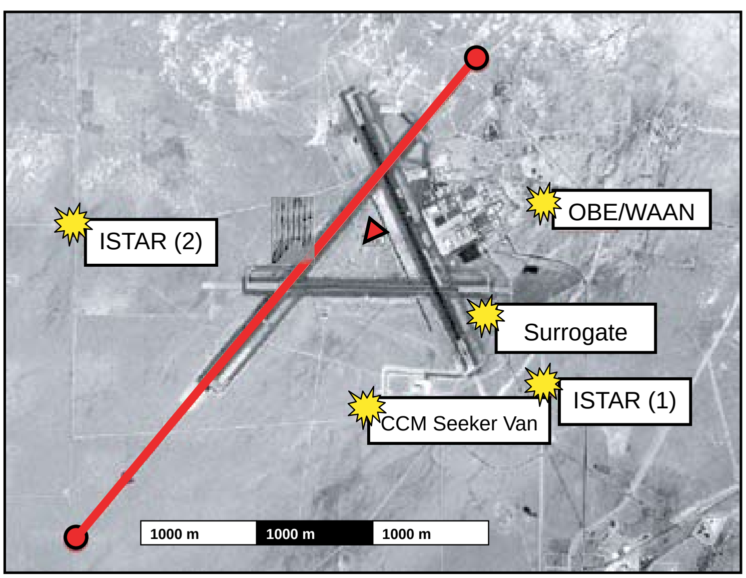

FIGURE 5
EOA testing configuration at the China Lake Naval Air Station.

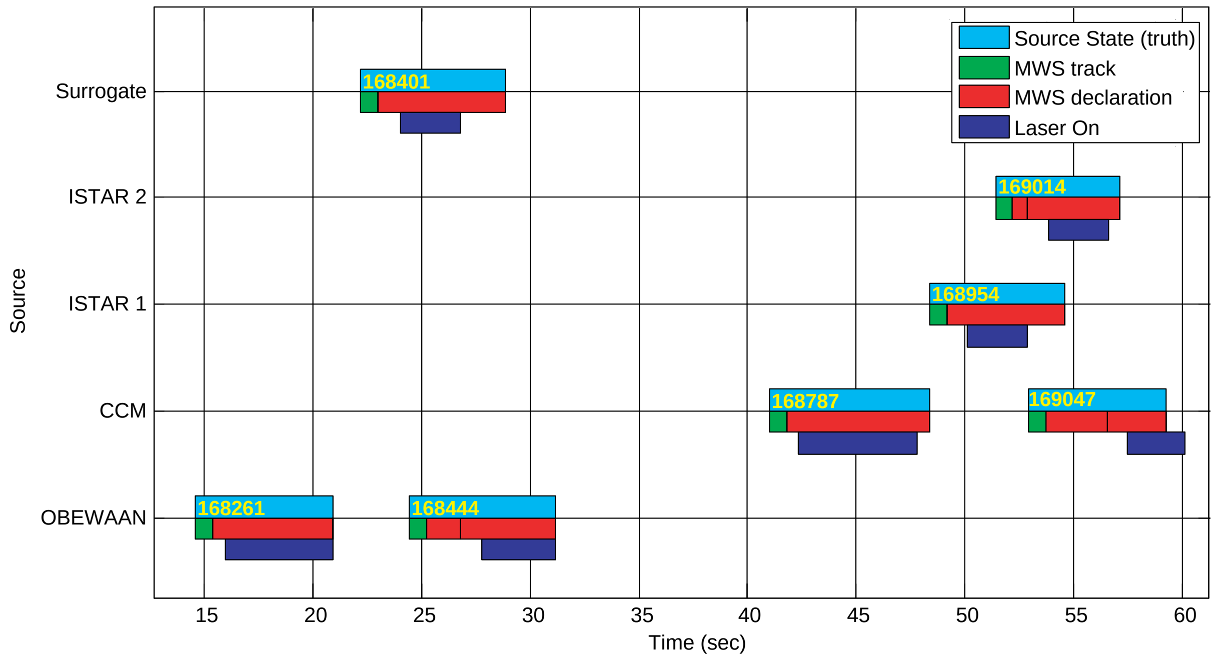

FIGURE 6
Sample TADIRCM performance timelines.

TABLE 1 — Summary TADIRCM EOA Performance Metrics.

MWS	96%
IR Jammer	99%